



# Inventory & Monitoring Program

## Pacific Island Network Monitoring Plan

### **Supporting Documents: American Memorial Park Resource Overview**

Prepared by Allison Cocke  
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#### Pacific Island Network (PACN)

##### *Territory of Guam*

War in the Pacific National Historical Park (WAPA)

##### *Commonwealth of the Northern Mariana Islands*

American Memorial Park, Saipan (AMME)

##### *Territory of American Samoa*

National Park of American Samoa (NPSA)

##### *State of Hawaii*

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

## EXECUTIVE SUMMARY

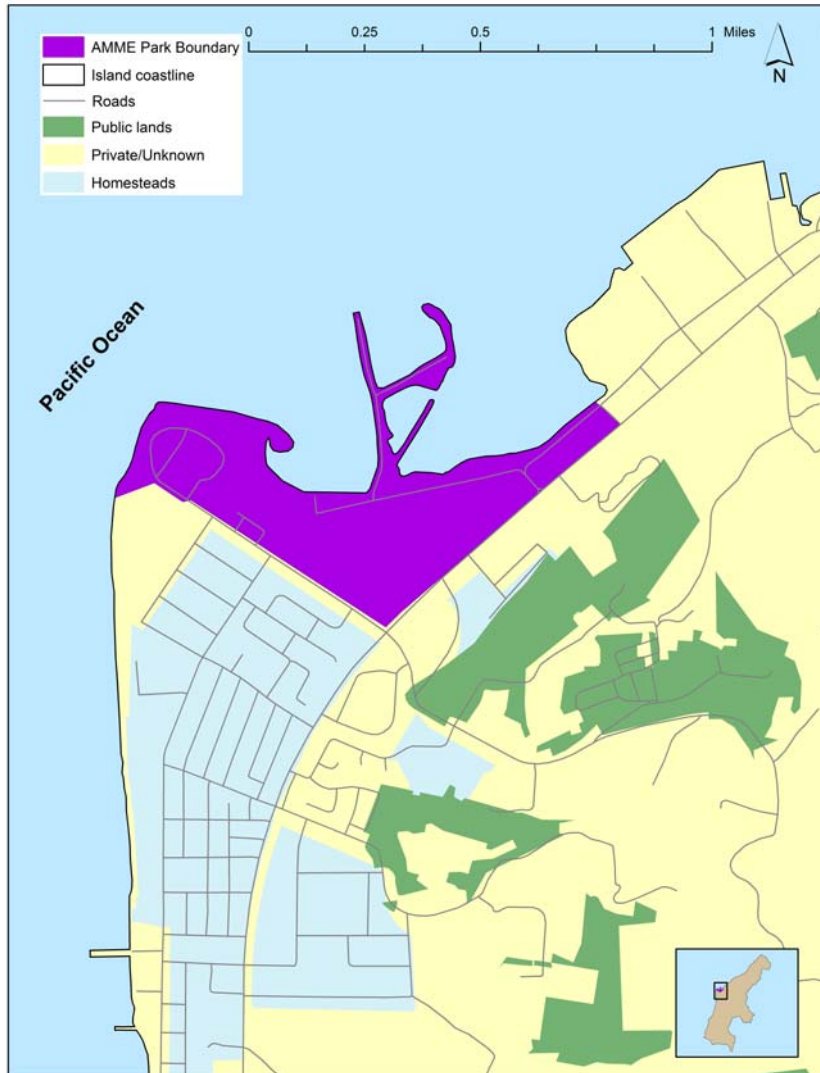
### **Enabling Legislation**

"On August 18, 1978 (P.L. 95-348), the U.S. Congress authorized and directed the U.S. National Park Service '...to develop, maintain and administer the existing American Memorial Park (AMME) located at Tanapag Harbor Reservation, Saipan. The park shall be administered for the primary purpose of honoring the dead in the World War II Mariana Island campaign'" (General Management Plan 1989). The U.S. National Park Service was further directed to provide interpretive activities at the park and interpret historical aspects in four languages: English, Chamorro, Carolinian, and Japanese. The primary use of interpretation would be a description of the World War II battle for Saipan and its relationship to the Pacific Theater as a whole. Secondary interpretive themes would encompass the ecological and environmental resources of the park. Lastly, the early history of Saipan could be interpreted to explain its relationship to subsequent historical events.

To find enabling legislation documents on-line follow the "Policy & Legislation" link from the Pacific Island Network website ([www1.nature.nps.gov/im/units/pacn](http://www1.nature.nps.gov/im/units/pacn)).

### **Geographic Setting**

American Memorial Park is on the island of Saipan within the Commonwealth of the Northern Mariana Islands (CNMI). The Mariana Island chain stretches from Guam toward Okinawa and Japan. The 133-acre park is on the west side of the island. Elevation ranges from mean sea level to 10 feet. Climate is tropical. Humidity is generally in the 80s, with temperatures ranging from 68 degrees F to 89 degrees F. Average annual rainfall is 83 inches. Saipan is repeatedly affected by typhoons (often several per decade), which have caused major damage in the past. Furthermore, the park lies in a floodplain. Most park visitors are local residents and the beach area experiences heaviest use. Recreation includes picnicking, swimming, fishing, boating, athletic events, and ceremonial use. Most of the adjacent landowners are private and include the Hyatt and Victoria Hotels. The park is bounded by public roads and the town of Garapan borders the south side. CNMI government owns Puerto Rico Dump/Lower Base on the northeast side of the park as well as the waters to the west and north including a beach and a boat harbor with an access channel created during World War II.



### **Significant Natural and Cultural Resources**

Coastal waters, including coral reefs, are not within the park's jurisdiction. However, a pending case before the U.S. Federal Court (Commonwealth of the Northern Mariana Islands v. U.S. Civil Action No. 99-0028 at 35, D. N. Mar. I., filed Aug. 7, 2003 ) could bring the nearshore waters within the jurisdiction of the park. The east side of the park contains native wetland composed of mangrove (*Bruguiera gymnorrhiza*), binalo (*Thespesia populnea*), hibiscus (*Hibiscus tiliaceus*), pluchea (*Pluchea indica*), nonak (*Hernandia sonora*), and fern (*Acrostichum*). Types of vegetation found within the park include mangrove swamps, marshes, strand, coastal scrub, and weedy scrub. Although not listed as endangered, the orchid *Zeuxine fritziican* can be found near the boundaries of the park and is potentially rare. Wildlife includes collared kingfishers (*Halcyon chloris*), Micronesian honeyeaters (*Myzomela rebratra*), bridled white-eyes (*Zosterops conspicillatus saypani*), golden white-eyes (*Cleptornis marchei*), rufous fantails

(*Rhipidura rufifrons*), and island swiftlets (*Aerodramus vanikorensis*). Several species including the nightingale reed-warbler (*Acrocephalus luscini*), moorhen (*Gallinula chloropus guami*), and Mariana mallard (*Anas oustaleti*), are listed as threatened or endangered. Migrant shorebirds are also common along the tidal flats. The beach within AMME was used by ancient Chamorro as a training beach for celestial navigators

### **Resource Management Priorities**

Due to the park's primary designation as a historic monument, natural resource management priorities center on recreational, environmental, and cultural resources. Near the park, the Puerto Rico dump is closed, although the impact of the dump on the surrounding ecosystems is being evaluated (see monitoring projects, below). Completed inventories around AMME exist for geology, soils, birds, and wetlands vegetation. Monitoring projects exist for earthquakes, erosion, birds, and water quality.

## NATURAL RESOURCES

### Focal Ecosystems and Processes

- Wetlands/mangroves
- Threatened and endangered species
- Coral reefs (not within park)
- Nearshore marine water (not within park)
- Shoreline dynamics
- Migratory birds

**Wetlands:** The inland mangrove-wetland complex is unique to the Marianas. This wetland has fresh water at the periphery and is saline in the center, suggesting a marine connection. Main wetland species include mangrove (*Bruguiera gymnorrhiza*), pluchea (*Pluchea indica*), Binalo (*Thespesia populnea*), beach hibiscus (*Hibiscus tiliaceus*), aquatic fern (*Acrostichum*), and nonak (*Hernandia sonora*). Saipan has only a single species of mangrove (*Bruguiera gymnorrhiza*), and nearly its entire distributional range on the island occurs within the park boundary. The AMME mangrove wetland has approximately 200 species of plants and animals, including two endangered species of birds, the nightingale reed-warbler (*Acrocephalus luscini*) and the Mariana common moorhen (*Gallinula chloropus guami*). Collared kingfishers, Micronesian honeyeaters, bridled and golden white, rufous fantails, and island swiftlets are often seen here. Adjacent to the wetland is the Puerto Rico mudflat, which serves as an important migratory bird.

**Threatened and Endangered species:** Federally listed threatened or endangered bird species include the Micronesian Megapode (*Megapodius laperouse*), the Mariana common Moorhen (*Gallinula chloropus guami*), the Mariana gray Swiftlet (*Aerodramus vanikorensis bartschi*), the Mariana Crow (*Corvus kubaryi*), the Nightingale Reed-warbler (*Acrocephalus luscini*), and Mariana Mallard (*Anas oustaleti*) (believed to be extinct). Other threatened and endangered species include Hawksbill sea turtle (*Eretmochelys imbricata*), Leatherback sea turtle (*Dermochelys coriacea*), green sea turtle (*Chelonia mydas*), loggerhead sea turtle (*Caretta caretta*), Guam rail (*Rallus owstoni*), and Tinian Monarch (*Monarcha takatsukasae*). The only federally listed plant is the Fire Tree (*Serianthes nelsonii*). Additional species listed by the Commonwealth are Micronesian Gecko (*Perochirus ateles*), Rota- Bridled White-eye (*Zosterops rotensis*), Cat's Tail (*Lycopodium phlegmaria* var. *logifolium*), Sheath-tailed bat (*Emballonura semicaudata*), and Marianas Fruit Bat (*Pteropus mariannus mariannus*). Two turtle species, Green and Hawksbill, have attempted nesting on AMME beaches in the recent past. It was believed that these attempts were "false nestings." However, in the late 1990s, large numbers of juvenile green turtles were found in the marina adjacent to the park boundary, suggesting that a successful nesting occurred nearby, potentially within the park.

**Coral reefs:** Although the reefs are technically not within the park's jurisdiction (see above), they are nevertheless a significant resource. Reefs in the Mariana Islands are diverse, well-formed, in good-to-excellent condition, and are moderately well studied. Some reef areas have experienced bleaching but high mortality was only documented in 2001 (Turgeon 2002). In the Mariana Islands there are 119 known species of non-scleractinian corals (Paulay et al. 2003), 377 species of scleractinian corals (Randall 2003), 26 species of hydrozoan coral (Randall 2003) and 1019 shorefishes (Myers and Donaldson 2003). The reefs near AMME lie within the Managaha Lagoon, the only true lagoonal system within the Mariana Islands. This lagoon is enclosed by an extensive, well-developed barrier reef system and is the location of Saipan's principal harbor. Investigations of coralline lethal orange disease, tumors, and black-band disease are being carried out (Turgeon 2002).

**Nearshore marine waters:** Nearshore waters around CNMI include over 150 algae species, 3 seagrass species, 1 mangrove species, 101 crustacean species, 15 echinoderm species, 30 annelid species, 520 molluscan species, 28 sponge species, and 11 ascidian species. Nearshore waters also include two gastropods which are endemic to the southern Marianas and Guam (Starmer et al 2002).

**Shoreline dynamics:** The sandy shoreline (Microbeach) is subject to fluctuating, predominantly natural, sand cycles which enlarge and contract over time. Erosion has been documented at the beaches within AMME, but it is currently believed to be a natural phenomenon. The Army Corps of Engineers conducted an assessment and made management recommendations to reduce beach erosion, but recommendations need to be carefully reviewed for their environmental impacts before implementation. A document discusses some of the historical changes in shoreline patterns and makes recommendations to stabilize the shoreline (Dean 1991). However, predictions from this document have not yet occurred, suggesting that shore may be reaching a stable state. Work has been started by park staff to assess the rate of beach erosion at the park. This work is being done in cooperation with CNMI Coastal Resource Management Office (CRMO).

**Migratory birds:** Several migratory birds have temporary residence within the park, including golden plovers (*Pluvialis dominica*), Pacific reef-herons (*Egretta sacra*), red-footed boobies (*Sula sula rubripes*), Mariana common moorhens (*Gallinula chloropus guami*), whimbrels (*Numenius phaeopus*), sandpipers (*Actitis*), and turnstones (*Arenaria interpres*).

### **Threats & Stressors:**

- Typhoons
- Earthquakes, tsunami, and volcanic activity
- Illegal dumping and abandoned equipment
- Effluent and Runoff
- Shoreline erosion
- Development and tourism

- Alien species
- Overfishing

***Typhoons:*** Typhoons can cause water damage from flooding and storm surge. They can impact coastal and inland areas, including wetlands and mud flats. They may also produce wind damage to forested areas that would disrupt ecosystem processes, along with tidal and coastal erosion which also impacts nearshore ecosystems.

***Earthquakes, tsunami, and volcanic activity:*** Earthquakes can potentially raise or lower local sea level, which might disrupt wetlands, uproot trees, and alter coastal habitats. Earthquakes from both proximal and distal sources may also generate tsunami. Volcanic ash from nearby active volcanoes is also a potential threat. Ash erupted from nearby active volcanoes (Anatahan, Pagan, Agrigan, and Farralon de Pajaros) can have a significant impact on AMME if the ash plume were to drop ash onto the park or nearby waters. Additionally, volcanic gas emissions from nearby active volcanoes affect air quality.

***Illegal dumping and abandoned equipment:*** Rubbish dumping continues to occur in the park. In the past, the wetland had been affected by filling and waste oil ([www.wetlands.org](http://www.wetlands.org) accessed 7/13/2004). A report on oil remediation in the park was recently finished by the Army Corps of Engineers (2004).

***Effluent and Runoff:*** A stream-like ditch running along the western edge of the park receives runoff and effluent from the Hyatt Hotel desalinization facility, which is regulated by the Environmental Protection Agency (EPA) under its national Pollutant and Elimination Discharge System (NPDES) program. Despite this monitoring and permitting process, CNMI standards maintain that the salinity of discharged water should not affect a change in the ambient salinity of the recipient waters. All permittees are presently injecting their water into deep wells, and it is hoped that by mid-2004, runoff wastewater will no longer be discharged into the ditch. The Hyatt is in the process of completing its injection wells which should be complete in late 2004 and will divert their discharge from the channel. The channel is being expanded to handle additional runoff from Garapan which is undergoing renovation to alleviate flooding problems. As part of the channel expansions, CNMI is installing an artificial wetland systems (still in the planning phase). Water quality in AMME is also affected by the nearby Puerto Rico Dump. Further illegal dumping, a public marina, and leakage or seepage from abandoned fuel tanks and military equipment, are all threats to water quality.

***Shoreline erosion:*** As above, erosion may be a natural process within the park. Erosion has been documented at the beaches within AMME, but it is currently believed to be a natural phenomenon. The Army Corps of Engineers conducted an assessment and made management recommendations to reduce beach erosion. Historical changes in shoreline patterns and recommendations to stabilize the shoreline are documented in Dean (1991). Work has been started by park staff to assess the rate of beach erosion at the park.

**Development and tourism:** The nearby town of Garapan experiences increased development. Paved areas in and near the park increase sedimentation in nearshore waters (Starmer et al. 2002). The park is heavily used during celebrations such as the annual Flame Tree and Liberation Day Festival. The most important stressors caused by development and tourism include trampling, illegal harvesting of vegetation, and rubbish dumping.

**Alien species:** Most of the park is dominated by alien plant species except for the native wetland. Wetland areas are at risk for invasion of weedy plants, which may alter the structure of vegetation communities. Invasive vines, scarlet gourd (*Coccinia grandis*) and chain-of-love (*Antigonon leptopus*), are overgrowing the edge of the wetland. Introduced mosquito fish (*Gambusia affinis*) and tilapia (*Sarotherodon mossambicus*) also impact wetlands. AMME is in the process of inventorying its mangrove and wetland ecosystems and until that is complete, the severity of the invasive species problem is unknown. However, the potential for these ecologically and economically destructive species to be present in the park is high and it is urgent that the park assess the distributions of alien or invasive species and formulate management strategies after the initial inventories are completed. Off-shore, many aquatic and semi-aquatic vascular plants and marine or brackish algae have been identified as invasive species on Pacific islands. Feral animals also pose threats to native ecosystems; these include cats, rats, and dogs. The brown tree snake (*Boiga irregularis*) has been seen on Saipan and is a potential threat, especially to native birds. The introduced monitor lizard (*Varanus indicus*) is also a threat to ground-nesting birds.

**Overfishing:** Fishing is popular on the reef areas around the park. Questionnaires found common catches of empororfish, tuna, grouper, ee, parrotfish, and octopus. Other harvests include various clams, crabs, and algae. Overfishing may be aided by illegal fishing with dynamite and chlorine, taking juvenile fish, and no creel limits (Micronesian Environmental Services 1997). Due to various types of surveys, it is difficult to determine exactly how much fishing is occurring, as well as the resulting abundances of certain species.

### **Water Quality Designations**

Under the jurisdiction of the CNMI, Division of Environmental Quality (DEQ), Saipan has two classifications (AA and A) for marine waters, and two for fresh surface water (1 and 2). The coastal waters of AMME to the North of Puntan Muchot are considered Class A waters “protected for their recreational use and aesthetic enjoyment. Other uses are allowed as long as they are compatible with the protection and propagation of fish, shellfish, wildlife, and recreation in and on these waters of a limited body contact nature.” The AMME coastal areas south of Puntan Muchot are Class AA; to remain in their natural state with a minimum of alteration and no dumping permitted. AMME fresh waters are class 1 carrying the objective of an absolute minimum of human influence and the prohibition of wastewater discharges and mixing zones for these waters. At this time, groundwater quality management zones are being developed to protect the island’s drinking water sources. Because the Commonwealth is almost entirely dependent on



ground water for its drinking water supplies, regulations set water quality standards for land disposal activities to ensure the protection of this natural resource. At this time, requirements for land disposal activities will be dependent on vertical distances to the aquifer, lateral distances to nearby water wells, and general quality of existing ground water until specific groundwater quality management zones are developed (see [http://www.epa.gov/ost/standards/wqslibrary/territories/northern\\_mariana\\_9\\_wqs.pdf](http://www.epa.gov/ost/standards/wqslibrary/territories/northern_mariana_9_wqs.pdf) for full details). In April 2004, DEQ published proposed changes to the CNMI Water Quality Standards that included revisions to the microbiological criteria and anti-degradation policy. The CNMI DEQ water quality standards are available at [http://www.epa.gov/ost/standards/wqslibrary/territories/northern\\_mariana\\_9\\_wqs.pdf](http://www.epa.gov/ost/standards/wqslibrary/territories/northern_mariana_9_wqs.pdf). Outstanding Natural Water Resources have not been designated in the Pacific Islands. However, the wetlands are considered a unique/pristine resource. 303d waters (impaired) only include Saipan Lagoon.

## CULTURAL ISSUES

Light pollution has become a problem in AMME due to the lighted walkway along the beach. Night sky is a culturally significant feature because ancient Chamorro used beaches for teaching navigation; the beach within AMME is one of the few spots on the islands where  $\frac{3}{4}$  of the sky can be seen to the horizon with no land in the way.

## MANAGEMENT ISSUES

### Park Management

The park places emphasis on sports facilities, swimming facilities, and marine, botanic and cultural facilities. Planning objectives include development exclusively for memorialization, recreation, environmental, and cultural activities. Activities are limited to locations within the park that are compatible with those activities, so as to protect and preserve the primary historic, natural, terrestrial, and marine park resources.

Park management documents (General Management Plan, Resource Management Plan, etc.) are available on-line at the NPS intranet site ([http://www1.nrintra.nps.gov/im/units/pacn/parks/mgmt\\_docs.htm](http://www1.nrintra.nps.gov/im/units/pacn/parks/mgmt_docs.htm)). This website is available only from NPS computer networks. Inquiries about public access should be directed to the park.

**Maintaining wetlands and marine waters:** Wetlands must be maintained as natural areas to restore and maintain endangered and indigenous species, with visitor access through walkways. The impact on the park from the Puerto Rico mudflats and dump should be better understood and therefore monitoring is needed. Priorities need to be re-evaluated pending the decision of the aforementioned legal action, if marine waters abutting the park should become under their jurisdiction.

**Exotic species:** Exotic species will be removed or controlled.

## INVENTORIES

### **Existing Inventories in Park**

**Vegetation:** Falanruw et al. (1989) mapped vegetation using 1976 aerial photos. Raulerson and Rinehart (1989) mapped the vegetation of American Memorial Park using a 1987 aerial photograph and data from four transects surveyed in 1986 and 1988. This research may be considered a baseline for alien plant monitoring. A wetlands survey in 2001 included an inventory of plant species (Raulerson and Witteman, in prep.).

**Terrestrial Vertebrates:** Nesting research of nightingale reed-warbler was conducted by Mosher and Fancy (2002). Johnson (2003) recently completed a study on the nightingale reed-warbler, and to a lesser extent the Mariana moorhen.

Individuals of the candidate endangered humped tree snail (*Partula gibba*) were recently discovered in the wetland.

**Geology:** Beach erosion was investigated in American Memorial Park by Dean (1991).

**Water Quality:** Six EPA stations within American Memorial Park were used for wetland hydrology testing in 1990 (Wagner 2001).

### **Priorities for New Inventories in Park**

A comprehensive inventory of marine plants and animals is needed for AMME and an inventory of terrestrial invertebrates needs to be completed. The results of the inventory of wetlands need to be completed and integrated into a management plan. A biological inventory should be conducted in the stream, and results integrated into a water quality monitoring and management plan. Monitoring for and response to invasive species such as the brown tree snake and known invasive plant species is crucial for the maintenance of this unique ecosystem.

A hydrologic study of the wetland in the park has been funded for 2005 by the National Park Service Water Resources Division. The U.S. Geological Survey Water Resources Division in Saipan will conduct the work through an interagency agreement. In addition, a biologic study of the Puerto Rico mudflat has been funded by American Memorial/ War in the Pacific for 2004.

### **Buffer Zone Inventories**

**Vegetation:** Moore et al. (1977) mapped and inventoried seven wetland sites on Saipan. Trees and shrubs of the islands were surveyed (Raulerson and Rinehart 1991), as were orchids and ferns (Raulerson and Rinehart 1992). In 2003, the park funded a project to

map and inventory the mangrove swamps within the park boundary (Raulerson and Witteman *in prep*).

**Terrestrial Vertebrates:** Birds for Saipan were described by Baker (1951) and Pratt et al. (1979) described the status of many endemic species. A forest bird survey by Engbring et al. (1986) included surveys of native forest birds, seabirds, introduced species, waterbirds, shorebirds, and domestic birds. General ornithological surveys of wetlands were conducted by Tenorio and Associates (1979). A study on migrant shorebirds was carried out by Stinson et al. (1997). Other studies include Saipan birds checklists (Owen 1977, Pyle and Engbring 1985, Reichel and Glass 1991), survey on endemic avifauna (Marshall 1949), nightingale reed-warbler (US Fish and Wildlife Service 1997), golden white-eye nest and clutch (Stinson and Stinson 1994), megapode (Pratt and Bruner 1978), and Mariana mallard (Yamashina 1948). In 1982, a study in cooperation with the Commonwealth Division of Fish and Wildlife, was conducted on Saipan to survey the abundance and distribution of forest birds.

Fauna surveys from Saipan also include a report on the status of the Marianas fruit bat (*Pteropus mariannus*) (Wheeler 1980) although no bats were actually encountered on Saipan.

Other faunal studies include reptiles and amphibians (Rodda et al. 1991). Descriptions include those African snail and other mollusks (Lange 1950), two new species of parasitic wasps (*Anagyrs*) (Doutt 1952), and coconut beetle (Lange 1950). Surveys were also carried out by Sengbusch (1984) in which they identified some new mite species (*Annectacus* and *Lohmannia*). Land snails of the family Partulidae were described by Crampton (1924) in a comprehensive study of partulids and further noted by Kondo (1970).

**Marine Communities:** Marine surveys in other areas of Saipan include those for creel (CNMI Division of Fish and Wildlife 1988 and 1993), coconut crabs (*Birgus latro*) (Amesbury 1980), marine plants (Fitzgerald and Tobias 1974), fishes (Trianni 1999, Houk 2001), fish and spawning areas (Amesbury et al. 1979), crown of thorns starfish (*Acanthaster planci*) (Goreau 1969 and 1972), collector urchin (*Tripneustes gratilla*) (Cloud et al. 1959), sea cucumbers (Chandran 1988, Tsuda 1996), seagrasses (Tsuda et al. 1977), agar-agar (Nelson et al. 1982), and sea turtles (Kolinski et al. 2001). Coastal Resource Management (CRM) and Department of Environmental Quality (DEQ) marine biologists conducted a habitat survey of the lagoon's southern half to understand potential sea urchin habitats, and collector urchin populations in these waters (Yuknavage 2001). An underwater survey was conducted in June 1986 of lagoon waters adjacent to the Puerto Rico Dump to determine the nature of the biological communities (Richmond and Matson 1986); this study found that the marine community adjacent to the dump is "normal" although the area southwest of the dump had high coral mortality. Ocean currents, vegetation, and wildlife were measured in 1987 in preparation for rehabilitation of the Smiling Cove Marina. Channel, inner basin, and reef-flat areas were surveyed, and checklists and relative abundances were recorded for marine plants, corals, and fishes

(PBEC 1987). Habitat and their correlations to fish were studied around Managaha Island (Tenorio 1999). From 1984 through 1988, the Division of Fish and Wildlife (DFW) conducted regular reef fish surveys to track changes in abundance and diversity (CNMI DFW 1988). A species checklist is maintained by the DFW (1994). Reef fish abundance were also sampled near AMME in the Managaha Marine Conservation Area (Trianni 2003). Studies of the power barge Impedence included marine plants (Tobias 1977), corals (Doty et al. 1977), mollusca and other benthic invertebrates (Dickinson 1977), zooplankton (Amesbury and Doty 1977), and fishes (Amesbury et al. 1977).

Observations and measurements of coral were made to determine coral density, dominance of substrate of living corals, and frequency of occurrence (Gawal 1974). Coral damage was assessed and water flow was studied in the Tanapag Barrier (Randall 1987). Coral reef areas have been summarized by Hunter (1995) and NOAA ([http://state\\_of\\_coast.noaa.gov/bulletins/html/crf\\_08/crf.html](http://state_of_coast.noaa.gov/bulletins/html/crf_08/crf.html)). The Managaha Patch Reef site was surveyed for benthic cover and coral communities before and after the Saipan Channel dredging project (UOG). A recent checklist for all coral species encountered during CNMI Inter-Agency Monitoring Team (MMT) is available (Houk 2001) with results similar to Birkeland et al. (1997). Data collected in this last survey include percent cover, coral colony diameter, water quality, and sedimentation rates. Mapping and monitoring of US coral reef ecosystems is also being done (<http://biogeo.nos.noaa.gov/projects/mapping/pacific/territories/data/> accessed 9/8/2004).

**Geology:** Geological studies in Saipan include Cloud et al. (1958) and Cloud et al. (1959). Cloud (1955) studied beach and terrain analysis and Eldredge and Randall (1980) also studied Saipan's reefs and beaches. Cloud (1959) analyzed submarine topography sand shoal water ecology. Other studies include a subsurface soil investigation of Smiling Cove Marina (Geotesting 1987), topography, geology, and related water resources (Cole and Bridge 1953), general geological surveys (McCracken 1953 and Young 1989), limestones (Johnson 1957), and volcanic rocks (Schmidt 1954 and 1957). Siegrist (1989) evaluated a potential source of fine-aggregate in limestone bedrock deposits located in northeastern Saipan, which follows an earlier extensive geologic reconnaissance and sampling-testing program carried out in 1988. Soils were studied by McCracken (1957), and McCracken and Zarza (1958); NRCS (1989) has published soil maps for Saipan. Hydrological studies include Davis (1958), Tenorio Engineers (1973), and van der Brug (1985). Paleontology studies include calcareous algae (Johnson 1957), discoaster (Bramlette 1957), radiolarian (Reidel 1957), foraminifera (Todd 1957 and Cole 1957), and echinoids (Cooke 1957).

**Water Quality:** A summary of hydrology data was produced for Saipan in 1998 (Carruth 2000). Studies of the power barge Impedence included sediments (Clayshults 1977), water motion (Marsh and Doty 1977), water temperatures and plant operation (Doty 1977), and oxygen and nutrients (Marsh and Ross 1977).

## MONITORING

### **Existing Monitoring in Park**

***Terrestrial Vertebrates:*** The Division of Fisheries & Wildlife currently monitors birds in the wetlands, including Christmas Bird Counts.

***Geology:*** The park has started a monitoring project of beach erosion, which is being done in cooperation with the CNMI CRM.

***Water Quality:*** The USGS Water Resources Division Hawaii District operates a network of water quality stations that collect information on streamflow, suspended sediment, lake and reservoir stage, groundwater level, salinity, rainfall, and evapotranspiration. The District also carries out interpretive studies on the quantity, quality, and dynamics of surface and groundwater (Hoffman 1995, USGS WRD 2003). Since 1994, DEQ has been monitoring water temperature, dissolved oxygen, pH, salinity, phosphate, total phosphorous, silicate, nitrate, nitrite, turbidity, and human health parameters. These have been monitored since 1994 on beaches for human health purposes.

### **Priorities for New Monitoring in Park**

The stream in the park receives saline effluent from a desalinization plant and pollutants from a nearby town, affecting its suitability as habitat for invertebrates. Water quality monitoring for the stream should include the presence and abundance of stream-breeding insects and snails. The status of the alien ant community also deserves attention. Established transects could be used for timed-flight observations of dragonflies and other potentially sensitive native arthropods, as well as bait-station monitoring for ants and snail searches.

An important monitoring need is to follow changes in the wetland community. Baseline transects were established in the wetland in the late 1980s, and additional vegetation studies have recently been completed.

### **Buffer Zone Monitoring**

***Marine Communities:*** A commonwealth coral reef task force conducts extensive coral reef monitoring. This program is relatively new, but agencies and personnel involved hope to make this a long-term monitoring effort. The CNMI monitoring team (MMT is composed of CRM, DEQ, and DFW) monitors 9 sites offshore, one of which includes the Managaha Reef, for benthic coverage, coral communities, fish and macroinvertebrate abundance, biodiversity of corals and fish, and sedimentation rates (Houk 2001, Bearden et al. 1994). Approximately 20 sites were established for intensive data collection on a yearly basis. DEQ monitoring of 32 offshore locations inside Saipan Lagoon has been ongoing for 1.5 years. DFW is also looking at no-take Marine Protected Areas and the

effectiveness of ‘spillover’ effects of MPAs (Trianni 2003). The closest site to AMME includes the Managaha Marine Conservation Area.

The Commercial Purchase Survey collects commercial fisheries data on pelagic species, various invertebrates, and both shallow- and deepwater bottomfish which are marketed in Saipan (Micronesian Environmental Services 1997).

***Invasive Species:*** Monitoring for brown tree snake is conducted at ports in Saipan by the CNMI government. Activities generally consist of snake trapping, night time surveys, and canine inspections of incoming cargo. Snakes have been sighted on Saipan but it is not known if there is a breeding population.

***Geology:*** CNMI Emergency Management Office (EMO) records earthquakes at one site in Saipan. There are no long-term monitoring programs for volcanic activity. For the volcanoes north of Saipan, there are limited past and present monitoring efforts conducted by Hawaiian Volcano Observatory (HVO) and the CNMI EMO. These include geologic mapping, sampling of ash and lava flows for geochemical studies, Electronic Distance Measuring (EDM) for deformation monitoring, and seismic stations to gauge current activity.

***Water Quality:*** The University of Guam Water and Energy Resources Institute (WERI) conducts research projects on surface and groundwater quality, pesticide and heavy metal contamination, and soil run-off. WERI is involved with some water quality work in the Puerto Rico mudflat dump and the EPA is part of an effort to monitor and clean up the dump. The CRMO has initiated a sampling scheme around the dump site to detect the presence of toxic substances or residues in water, silt, and/or biological samples taken at designated stations in the vicinity of the dump (Bryan 1981). The DEQ conducts weekly monitoring of enterococci, fecal coliform, and nutrients near the Hyatt Hotel sewage outfall into the ocean adjacent to the park. They also monitor runoff at a site adjacent to the park boundary, and a storm water discharge basin created to prevent pollution runoff into the area near Smiling Cove Marina. Monitoring of wells near American Memorial Park is conducted by the Army Corps of Engineers. Water is also monitored by EPA at a number of sites across the island. Denton et al. (2000) studied sediments in Tanapag Lagoon including chemical analysis to determine levels of pollutants (heavy metals, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons). The CNMI MMT also monitors 9 sites offshore for water quality parameters (Houk 2001).).

In 2002, Saipan Lagoon was surveyed to assess effects of upland runoff. Aerial photographs were scanned and remote sensing techniques were used to delineate the habitats found. These are used to examine correlations between water quality, drainage areas, other areas of concern, and the lagoon habitat. Lagoon survey work is a joint project between NOAA’s CRM Program and DEQ.

***Other Monitoring:*** Weather is being monitored by the Meteorological Office and U.S. Weather Bureau. Stations are located at the airport and other points across the islands. No

stations exist within the park but two with minimal data collection are within 50 meters of the boundary.

## CONCLUSIONS

Designated as a historical monument, management priorities include maintenance of recreational, environmental, and cultural resources. Natural resources include coral reefs (not under park jurisdiction), a sandy beach, a stream and estuary, and a wetland. Primary threats to resources include tropical cyclones, high fishing pressure, recreational damage, increasing urbanization, invasive species, and chemical water and soil contamination. Preservation of this park is extremely important as endangered and endemic species exist within the wetland. The marine areas near the park include the only true lagoonal systems in the Marianas which gives way to high marine diversity. Future conservation efforts will be to improve water quality, maintain the native wetlands including the existing flora and fauna, and to add the marine areas to the park.

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